

Status, Impacts and Operations of High-Salinity Wet Cooling Towers

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Overview

- **Sponsor: CA Energy Commission Public Interest Energy Research Program**
- **Review of known or proposed CT's using seawater, brackish water, or other high-salinity sources**
- **Design and operating characteristics**
- **Environmental issues**
- **Specifics of some current installations, proposed projects**

Saltwater Cooling Towers in the US

Year	Owner	Site	Flow		Plant Size (@ 500gpm/MW)
			(m ³ /hr)	gpm	MW
1973	Atlantic City Electric Co. (NJ)	Beesley's Point	14,423	63,351	127
1976	Public Service Electric & Gas	Hope Creek	250,760	1,101,431	2,203
1981	Jacksonville Electric Authority	Jacksonville	112,520	494,230	988
1990	Florida Power Corp.	St. Petersburg	156,000	685,210	1,370
1992	Atlantic City Electric Co. (NJ)	B. L. England	16,280	71,508	143
1999	Florida Power Corp.	Crystal River	67,229	295,295	591
2000	St. John's River Power Park	Jacksonville (FL)	56,258	247,106	494

Brackish Water Cooling Towers in the US

Year	Owner	Site	Flow		Equiv. Plant Size (@ 500gpm/MW)	HWT	CWT	WB	Approach	Range
			(m ³ /hr)	gpm						
1953	Oklahoma Gas & Electric	Oklahoma	13,680	60,088	120	104.0	86.0	75.0	11.0	18.0
1964	American Salt Co.	Kansas	1,140	5,007	10	89.6	81.0	75.2	5.8	8.6
1968	Exxon Chemical	New Jersey	5,016	22,032	44	111.9	82.0	75.0	7.0	29.9
1971	Gulf Power	Florida	37,620	165,241	330	121.6	91.0	82.8	8.3	30.6
1973	Dow Chemical	Texas	13,680	60,088	120	109.0	86.9	80.1	6.8	22.1
1974	Potomac Electric	Chalk Point 3, MD	59,280	49	32	120.0	90.0	78.1	11.9	30.1
1975	Virginia Electric	Virginia	75,240	330,482	661	113.0	89.1	78.1	11.0	23.9
1975	Pfizer	North Carolina	12,442	54,650	109	100.0	87.1	80.1	7.0	13.0
1976	Dow Chemical	California	2,736	12,018	24	105.1	78.1	70.0	8.1	27.0
1976	Italco Aluminum	Washington	9,348	41,060	82	98.1	84.9	73.0	11.9	13.1
1976	Pacific Gas & Electric	Pittsburg, CA	84,816	372,543	745	100.0	82.0	70.0	12.1	18.0
1977	Houston Lighting & Power	Texas	54,720	240,351	481	109.9	94.5	82.0	12.4	15.5
1980	Mississippi Power	Plant Jackson	39,444	173,253	347	120.0	90.0	80.1	9.9	30.1
1981	Potomac Electric	Chalk Point 4, MD	59,280	260,380	521	120.0	90.0	78.1	11.9	30.1
1985	Palo Verde I	Arizona	133,836	587,857	1,176	118.8	87.3	77.0	10.3	31.5
1986	Palo Verde II	Arizona	133,836	587,857	1,176	118.8	87.3	77.0	10.3	31.5
1986	Stanton Energy #1	Florida	45,600	200,292	401	113.7	91.0	78.1	13.0	22.7
1987	Palo Verde III	Arizona	133,836	587,857	1,176	118.8	87.3	77.0	10.3	31.5
1987	Houston Lighting & Power	Texas	54,948	241,352	483	109.9	94.5	82.0	12.4	15.5
1989	Delmarva Power & Light	Delaware	46,170	202,796	406	116.8	90.0	79.0	11.0	26.8
1991	Delano Biomass	California	4,423	19,427	39	98.1	82.9	72.9	10.1	15.1
1995	Stanton Energy #2	Florida	45,600	200,292	401	113.7	91.0	78.1	13.0	22.7

Performance of Saline Cooling Towers

- **Higher salinity reduces CT performance**
 - “Rule of Thumb”- 5% capability reduction for a salinity of 50,000 TDS (Aull, R. **2005**)
 - CTI journal article suggesting a performance loss of 5.4% at a salinity of 50,000 TDS. Also refers to publication of a Fluor paper recommending increasing the design wet bulb by 0.055°C ($\sim 0.1^{\circ}\text{F}$) for each 4,000 ppm of dissolved solids. For sea water operating at 1.2 - 2 cycles of concentration, this corresponds to an increase in the design wet bulb of $0.55 - 1.1^{\circ}\text{C}$ ($\sim 1 - 2^{\circ}\text{F}$) - (Eftekharzadeh, S.; M. Baasiri; P/ Lindahl. *CTI Journal* **2003**, 24, 50-64)

Recommendations for High Salinity Towers

- Fiberglass structure – no timber. Reinforced concrete OK, too, but use epoxy coated rebar and proper concrete mix
- Low TSS seawater – use high efficiency fill, High TSS water – use inverted-V splash fill
- Metal components – epoxy coated carbon steel
- Hardware – silicon bronze with plastic caps for erosion protection, or 316SS (costly)
- Most use titanium condensers



Mirant Chalk Point Towers

Insights from Individual Facilities

Pittsburgh Plant, California

- Units 5,6,&7 – 1300 MW with helper tower
- TDS in summer as high as 17,000 mg/l
- Total hardness 1500-1700 mg/l CaCO₃
- High colloidal organics
- 1.3-1.4 COC all year long
- Winter: TDS 100-100mg/l, but TSS can be 200mg/l
- Wood tower with plastic, high efficiency fill,
- No bio control, pH control or scale/corrosion control
- Some thermal degradation in some cells, attributed to fill bypass

Insights from Individual Facilities (cont.)

Palo Verde Nuclear Generating Station, Arizona

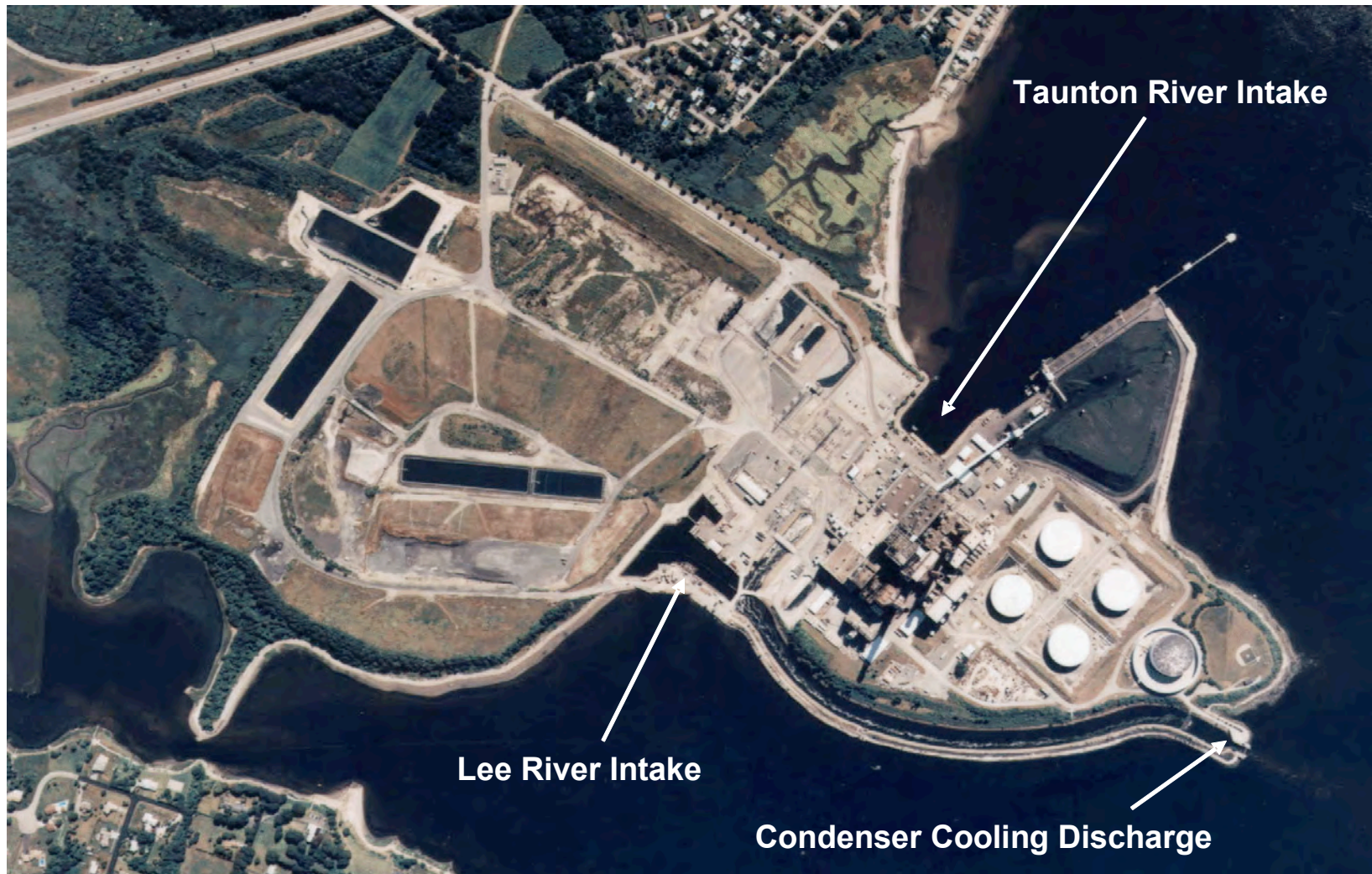
- Three 1300 MW units, circular cross-flow towers
- Secondary treated effluent from Phoenix
- Trickling filtration (organics, ammonia and TSS reduction), lime/soda ash softening, final filtration
- Operated at 24 COC, sometimes to 30 COC
- CT's are reinforced concrete, chloride attach on CS rebar, everything else is FRP/plastic, SS hardware
- Sulfuric acid to pH control of 6.9-7.4, scale inhibitor, TSS 10-50mg/l, sodium hypochlorite

Insights from Individual Facilities (cont.)

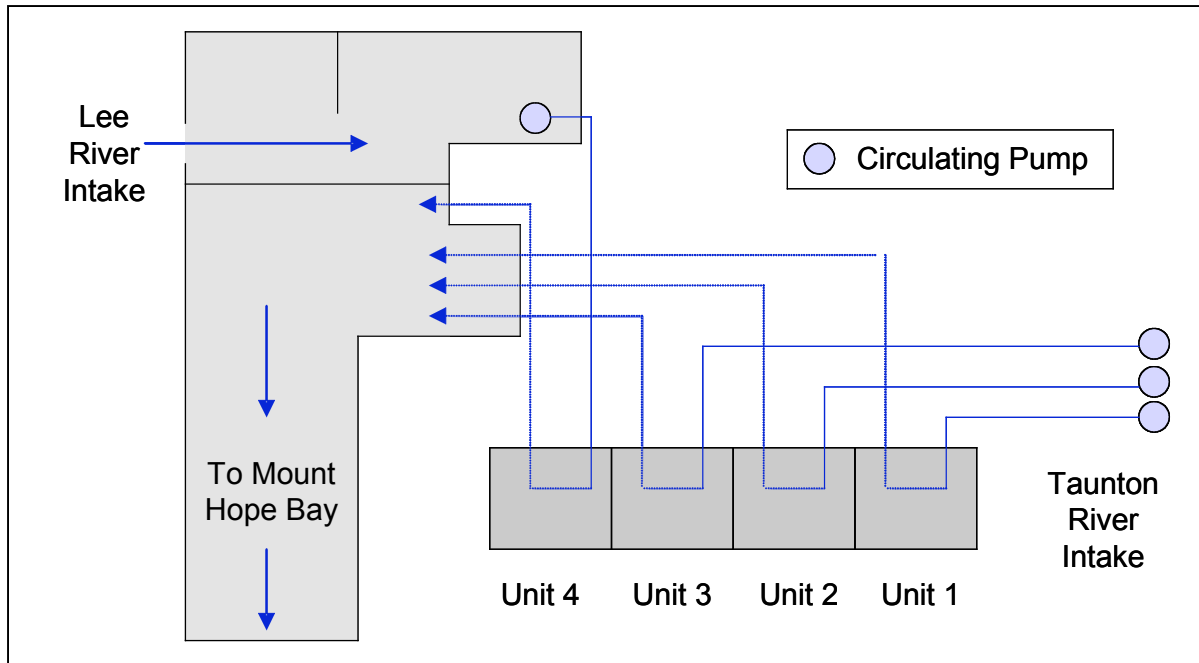
Brayton Point Station; Somerset, MA

- 1600 MW, 4 units
- Mount Hope Bay for cooling water
- Units 1-3 from Taunton River, Unit 4 from Lee River
- Enhanced Multi-Mode System
 - Designed and proposed as part of NPDES renewal
 - 20 cell, counter-flow, mechanical-draft cooling tower
 - System allows for capture and removal of heat from hottest water from any unit
 - 33% reduction in cooling water withdrawal and heat load
 - Reduced entrainment and impingement would reduce adult equivalent fish losses by 40%

Aerial View of Brayton Point Station

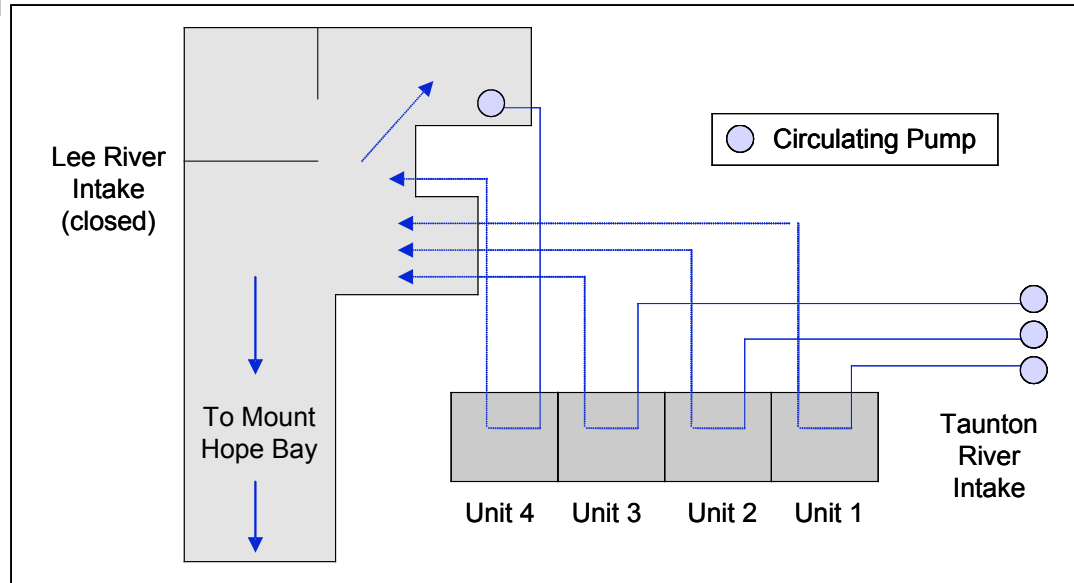


Existing Cooling System – Summer Operation



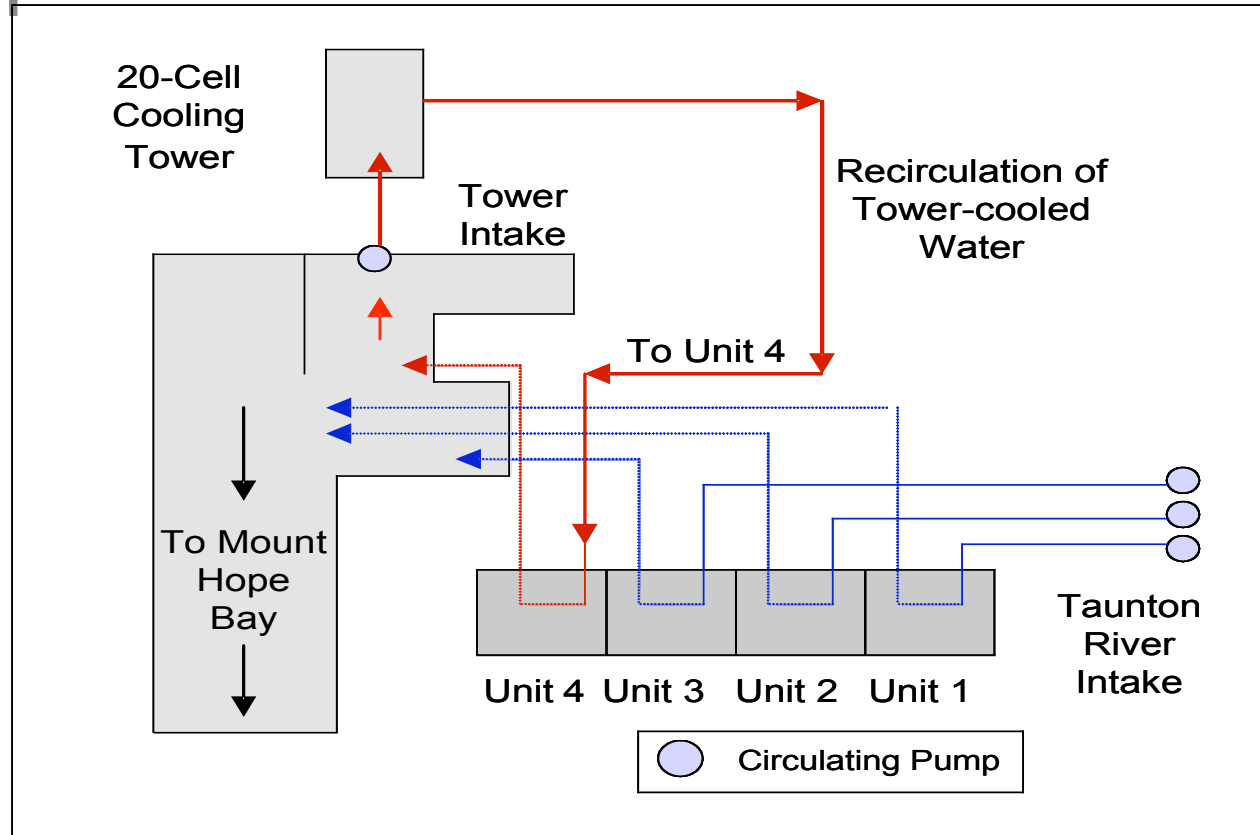
- June-September operation
- Max flow 1229 MGD

Existing Cooling System – Winter Operation



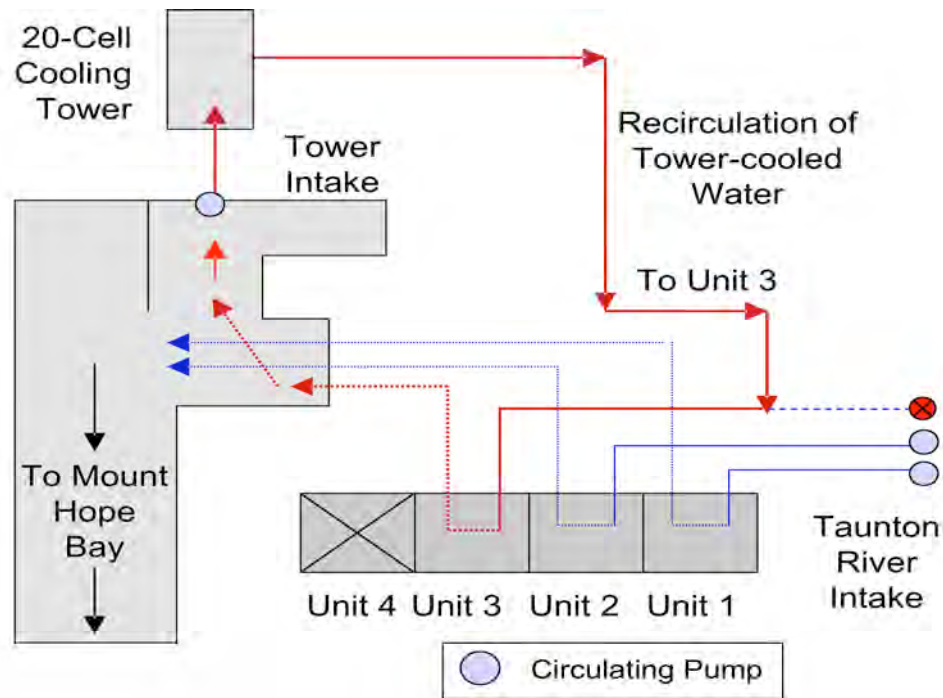
- October-May operation
- Max flow 925 MGD (winter flounder spawning)
- Station operates “piggyback” mode – discharge from U1-U3 used as cooling water for U4

Proposed EMM Operation – Unit 4 Closed Cycle



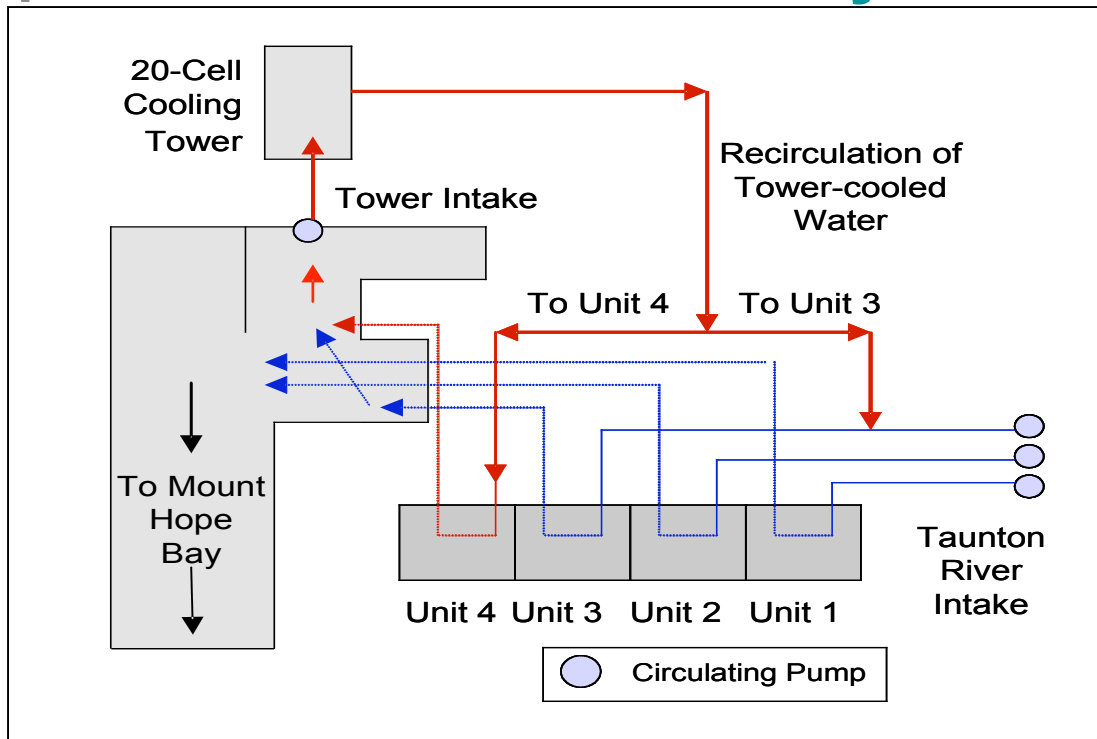
- Used when Unit 4 operating at full load
- Unit 4 circ water pumps used to circulate CW to tower

Proposed EMM Operation – Unit 3 Closed Cycle



- Used when Unit 4 is shut down
- Unit 3 circ water pumps shut down
- Cooling tower water recirculated to Unit 3 condenser

Proposed EMM Operation – Unit 4 Closed, Unit 3 Partial-Closed Cycle



- Used when Unit 4 operating at less than full load
- CT water recirculated to both Units 3&4
- Unit 3 – one CW pump on, one CW pumps off



- Used when Units 3&4 are off line
- CT acts as helper tower for Units 1&2
- Variable speed drives on Units 1&2

Brayton Point EEM Performance Estimates

- Cooling tower, circ water modifications and modified traveling screens (Units 1&2) estimated at \$57.4M (2001)
- Annual maintenance cost of \$240K
- Combined annual lost power generation – 97,900 MW-hr
 - 72,600 for aux power, 25,300 efficiency penalties
- July 7, 2004 – EPA Region 1 decision to require EEM
- Current permit expired 1998
- Decision is under administrative appeal by plant owners